DETAILED DESIGN REQUIREMENTS TEST PLAN

SAN MATEO COUNTY SMART CORRIDORS PROGRAM

FOR

SMCTA / CALTRANS / C/CAG

Prepared by:

URS

SEPTEMBER 18, 2009

VERSION: 23000.004

DETAILED DESIGN REQUIREMENTS TEST PLAN

1.0 Introduction and Background

1.1 Introduction and Background

The City/County Association of Governments of San Mateo County (C/CAG) and the San Mateo County Transportation Authority (SMCTA) in conjunction with the California Department of Transportation (Caltrans) has initiated an effort to address the operation of the freeway and arterial roadway network in San Mateo County. The San Mateo County Smart Corridor Program is intended to benefit a variety of users including commuters, local traffic, and commercial vehicle and transit operators.

The mitigation of the impacts of non-recurring traffic congestion on local streets within San Mateo County during major freeway incidents on US-101 was identified as a high-priority project in the Smart Corridor Program. A Project Report (PR) was written that proposes the deployment of integrated Intelligent Transportation System (ITS) elements to provide local agencies and Caltrans the tools to manage this congestion. The project includes the installation of the following ITS elements:

- Directional signs (trailblazer and turn prohibition) to direct traffic;
- Fixed or pan-tilt-zoom closed-circuit television cameras at intersections and midblock locations to monitor traffic congestion and end-of-queue location;
- Communications to provide interconnect between local agency traffic signals on local streets and State operated traffic signals on State routes;
- Upgraded traffic signal controllers and/or cabinets and signal operation software systems;
- Arterial changeable message signs to inform motorists of traffic conditions (also referred to as Arterial Dynamic Message Signs in this document);
- Center-to-center communications between the proposed San Mateo County Hub (SMCHub) and the Caltrans District 4 Transportation Management Center (D4TMC) (note where TMC is used in a general manner in this document, it refers to the SMCHub, the D4TMC and local TMCs);
- Vehicle detector stations (non-intrusive or intrusive technology) on non-freeway state routes (El Camino Real) and local streets at mid-block locations.

Many of these same elements can also be used to manage traffic along the corridor during recurrent congestion. In addition to the ITS elements noted above, the following ITS elements were identified for possible deployment on future projects:

- Transit priority service at intersections;
- Emergency vehicle preemption at intersections;
- Highway Advisory Radio (HAR) transmitters and signs;
- Advance warning signs at Caltrain at-grade crossings;
- Changeable message signs for arterial travel times.

A Concept of Operations (ConOps) was prepared in October 2008 and updated in September 2009, with input from local agencies and Caltrans, and direction from the Federal Highway Administration (FHWA). This is an initial step in the Systems Engineering process defined by the FHWA. The ConOps identifies the stakeholders, their roles and responsibilities, their coordination with each other, and how the system shall be developed.

1.2 Relevant Documents

Relevant documents include:

- FHWA/Caltrans Systems Engineering Guidebook for ITS, version 2.0, January 2007
- Final Draft ITS Infrastructure Improvement Plan, San Mateo County Alternative Route Plan, January 2008
- Draft Project Report in San Mateo County on US-101 and SR-82 from I-380 to the Santa Clara County Line, San Mateo County Smart Corridors, EA 4A9200, October 2008
- Project Study Report to Request Programming in the STIP for Phase 1of the San Mateo County Smart Corridors, March 2008
- San Mateo County Smart Corridors Projects Traffic Light Synchronization Program Funding Application March 2008
- San Mateo County Arterial Route for Traffic Incident Guide, February 2009
- San Mateo County Smart Corridors Program Concept of Operations, September 2009
- System Engineering Management Plan, San Mateo County Smart Corridors Program, version 10000.004, September 2009
- Functional Requirements, San Mateo County Smart Corridors Program, version 12000.007, September 2009
- High Level Requirements, San Mateo County Smart Corridors Program, version 13000.003, September 2009
- Detailed Design Requirements, San Mateo County Smart Corridors Program, version 13500.004, September 2009

Definitions and acronyms in this document are defined in the System Engineering Management Plan noted above.

2.0 Scope of Project

The goals of the project identified in the Concept of Operations have been modified as shown in **Table 1**.

Table 1 – Project Goals

Goal Area	Smart Corridors Program Goals
Traffic Incident Management	• Proactively manage traffic already diverted from the freeway to minimize impacts on local arterials, and return regional traffic back to the freeway as soon as possible by:

Goal Area	Smart Corridors Program Goals
	○ Actively managing traffic signal operations on selected routes to maximize traffic flow around a major incident and minimize delays caused by diverted freeway traffic. ○ Improving collection of current travel condition information along local arterials on the alternate routes. (Future) ○ Providing accurate and timely route guidance information about the corridors to agency transportation managers. (Future) ○ Minimizing the intrusion of freeway traffic on local streets due to major freeway incidents.
Interagency Coordination	• Provide the capability for shared control and operation of the Smart Corridors components by the agencies. • Improve sharing of resources between agencies for more unified transportation management operations across jurisdictions. • Improve communications between the agencies during major freeway incidents.
Traffic Operations and Management	• Improve traffic flow within the corridor during normal operation • Share traffic information between the agencies to improve coordination and management of traffic during normal operations

3.0 Purpose of Document

3.1 Identify objectives of testing
3.2 Describe test methodologies
3.3 Provide a test plan matrix for the detailed design requirements
3.4 Confirm that requirements can be tested

4.0 Test Methodology

4.1 Background

Testing shall occur through use of the applicable portions of the San Mateo Smart Corridors System and the associated display system whether they are in the field or in a Transportation Management Center (TMC). System acceptance testing shall occur after successful completion of the testing of each individual field element, its integration into its subsystem and the integration of the various subsystems.

The following Subsystems are expected to be deployed as part of the San Mateo Smart Corridors Program:

- Traffic Signal Subsystem to support traffic control.
- Directional Signs Subsystem to disseminate directional arrows on alternate routes or to prohibit turn movements.
- Arterial Dynamic Message Signs (ADMS) Subsystem on arterials for information dissemination.
- CCTV Cameras Subsystem to provide traffic surveillance and incident management verification.

- Detection Subsystem to provide traffic flow monitoring and traffic control data.
- Communications Subsystem to transport data and video images to/from field elements and the TMCs.

The System and the associated Subsystems are expected to incorporate the following types of devices:

- CCTV cameras with camera controllers in cabinets
- ADMS with sign controllers in cabinets
- Directional signs with control devices (either in a cabinet or as part of the sign)
- Vehicle detector stations with detectors in/over the roadway and amplifiers in a cabinet
- Traffic signal controllers in cabinets
- Communication networks including cabling, patch panelsl, modems, transceivers or network devices including Ethernet switches and terminal servers in cabinets and racks
- TMC equipment including servers, workstations and network equipment

System testing and design covers the integration testing that is required to validate the operational performance of equipment and software. For this project, there shall be minimal software creation or hardware development. To reduce project costs as well as risk, all software and hardware scheduled to be used shall be commercial-off-the-shelf (COTS) applications.

Testing shall be performed by the selected contractor on the System and its components to validate the functionality of the field devices provided by the contractor. This functionality shall be end-to-end and shall show that the devices can be controlled and monitored by the applicable TMC. The exact testing to be performed shall be detailed in the individual device acceptance test plans and in the system acceptance test plan.

Successful completion of a test will be based on meeting the performance criteria specified or provision of the functionality specified.

4.2 Methodology of Testing

4.2.1 Overall Methodology

The contractor shall test all integrated system functions to demonstrate that all communication connections and all ITS elements satisfy the functional and performance requirements of the specifications. Functional and performance testing shall include testing of each individual ITS element. The connectivity of each fiber shall also be tested and accepted as shall each radio frequency.

Testing shall consist of a building block approach where individual ITS elements, such as cameras, are first bench tested followed by field installation tests. Once the individual element passes the individual tests, it is then tested as part of a subsystem using standalone systems or other means, followed by the System Acceptance Test (SAT) using

the system installed at the various TMCs. *(Note that the San Mateo County Hub is intended as a backup for the Caltrans District 4 TMC and will be referred to as a TMC in this document for simplicity. The term TMC in general will also include future local agency TMCs and the D4TMC.)* Acceptance testing may be performed on portions of the system to allow for partial acceptance. However, at project completion, a System Acceptance Test (SAT) shall be performed on the entire System using the various TMCs.

The contractor shall document all functional and performance test results. In the event that any aspect of the functional or performance tests has failed, the contractor shall terminate all acceptance testing and determine the cause of the failure. If the failure is due to a defect within a contractor-furnished portion of the system, the contractor shall make repairs. Acceptance testing shall, under the conditions of the specifications, be repeated from the start of functional/performance tests. All material and software, except test equipment and software and special tools, shall be bench-tested for each individual item where applicable.

The contractor shall develop the set of testing definitions, guidelines and methods to be used to determine whether the implemented design satisfies the defined physical and functional requirements as well as the hardware and software performance specifications. These criteria shall include qualitative and quantitative metrics to facilitate the evaluation of acceptable functionality and performance. The test criteria shall reflect the defined physical and functional requirements as well as the hardware and software performance specifications and include definitions for test acceptance (pass) and test rejection (fail). The tests shall contain a description of the test methods to perform the testing activities and apply the specific evaluation criteria to be used to satisfactorily verify that the implemented design meets or exceeds the system requirements.

Where portions of the test have been previously performed, such as bench-testing, these results shall be included in the test report and not repeated.

These test methods used as part of testing shall be identified in the test plan and procedures and shall be categorized into the following areas with a brief description of these methods described in the following paragraphs:

- Demonstration
- Visual inspection
- Analysis
- Simulation

The demonstration method exercises the function or item under test using either real world or controlled environments and data parameters, in a manner which represents real world, operational use. Depending upon the function or item under test, some tests may not represent the daily perspective of the operator. The test may exercise a function that is executed in a background process and is transparent to the operator within daily system operations.

The visual inspection method is typically used to verify that the implemented design's physical characteristics satisfy the defined requirements and specifications.

The analysis method is typically used to verify functional outputs that need to satisfy defined formats, or whether specific conditions or operational states have been established.

The simulation method is typically used to demonstrate the design and output results of an algorithm when traditional methods of testing cannot effectively verify satisfaction of a requirement or specification. It is not expected to be used on this project.

4.2.2 Testing Process

Testing includes the preparation of a test plans, conducting tests and subsequent retests, and documentation of the results. These tests include observing and operating the system or the parts thereof in normal operations.

Testing is subject to the following conditions:

- Detailed test plans shall be developed containing all test procedures ranging from pre-installation bench tests through subsystem testing for each type of equipment
- Pre-installation tests need to be successfully completed prior to initiating any subsystem testing
- Testing shall be conducted by the contractor and observed by the Project Team (which consists of representatives of C/CAG, Caltrans and SMCTA)
- All test results, whether failed or retested, shall be documented and delivered to the Project Team

4.2.3 Performing Testing

Testing consists of a series of tests that involve a building block approach. Individual components first undergo a factory certification test. This is followed by a pre-installation test on each component, typically a bench test. Following this, field tests are conducted on each component to ensure that the unit is still functioning. Lastly, like components are grouped together in their respective subsystems and the subsystems are tested as a whole. The following sections on factory testing, pre-installation testing and field testing provide further details on subsystem testing.

Documentation shall be in accordance with the specifications and shall include the following, as appropriate:

- Alignment measurements
- All strap and switch settings
- Identification of interconnections
- Model and part number for all material
- Record of all adjustments and levels
- Test equipment and software model number, serial number, settings and date of last calibration

As noted above, the methodology of the testing process is based on a building block process. This involves the following sequence:

- Factory testing
- Pre-installation testing (bench testing)
- Field testing of the individual components as a local subsystem
- System testing of the individual subsystems during system integration
- System acceptance test
    - Satisfactory completion of the test plan matrix

4.3 Testing

Testing will consist of a building block approach as previously noted**.** The building block approach consists of the following:

- Factory testing
- Pre-Installation testing
- Field (standalone) testing
- Subsystem Testing
- System Acceptance Test

Throughout the testing process, the Test Plan Matrix (see Appendix A) should be used to track progress of each test and ensure that the Detailed Design Requirements are being met. Once all Subsystems have demonstrated successful completion of all testing, including being documented in the Test Plan Matrix, then the System Acceptance Test can begin. *Note that certain items in the Detailed Design Requirements can only be tested when the System is being tested as a whole.*
The following sections discuss each of these items.

4.3.1 Factory Testing

Factory testing shall be performed by the manufacturer on at least one unit of material selected at random from the normal production run. The full performance test shall be performed in accordance with an approved test plan. The tests shall demonstrate that the design and production of the hardware and software meets the requirements of the contract. Full environmental conditions shall be tested as part of the functional tests for field hardware and software. Upon request, the contractor shall provide the Project Team with the necessary documentation from the manufacturer to demonstrate specification compliance on contractor-supplied hardware and software.

4.3.2 Pre-Installation Testing

The contractor shall conduct component checkout testing and pre-installation bench testing on equipment provided by the contractor (as opposed to equipment provided by Caltrans) to verify that all hardware and software satisfies the physical specifications and functional and performance requirements. This testing shall be conducted at a location selected by the contractor. As a part of this activity, the contractor shall also demonstrate, prior to procurement, that each ITS field element is functionally compatible and interoperable with the communications and control interfaces and protocols currently installed and used by the Caltrans District 4 TMC for each respective device. All active

hardware and software shall be connected to normal operating power, energized and subjected to normal operating conditions for a burn-in period of at least 72 hours.

4.3.3 Field Testing (Standalone)

The contractor shall conduct site-level installation and integration checkout testing for each ITS element installed in the field. These tests shall occur after pre-installation testing has been successfully completed at each ITS field site and prior to connecting to the communications network. The contractor shall demonstrate conformance to the requirements. This shall include verifying the make/model, location, and the local functionality of the equipment. This testing shall take place at the local cabinet or Hub.

4.3.4 Subsystem Testing

Following completion of the field testing, the contractor shall test each subsystem as a whole. These tests shall occur after pre-installation testing has been successfully completed at each ITS field site. This testing shall involve testing at the various TMCs using the System to ensure that each ITS device can be controlled and monitored per the requirements of the specifications.

Subsystem testing includes, but is not limited to, the results of:

- Fiber optic and wireless network performance tests
    - Power levels and attenuation using optical time division reflectometers (OTDR)and optical power meters (OPM)
    - Bit error rate testing (BERT)
    - Frequency spectrum analysis
    - Network configuration and end-to-end connectivity (ping, etc.) tests
- Video link testing
    - Video signal waveform tests
- Data link testing
    - Data packet transfer testing
- Detection data validation using local equipment and the System
- Camera selection and control using local equipment and the System
- ADMS and directional sign selection and control using local equipment and the System

The contractor shall test the communication Subsystem according to the approved system acceptance test plan and shall provide all test equipment and software, labor and ancillary items required to perform the testing. The test equipment and software shall be certified to be calibrated to the manufacturers' specifications. The model, part numbers and date of last calibration of all test equipment and software shall be included with the test results.

The contractor shall analyze the results of Subsystem testing on all hardware and software and shall record the test and analysis results. The contractor shall review these results to check if the Subsystems operate as expected and measure the equipment and software correctness, reliability, quality and performance. If a Subsystem fails, the Subsystem testing, the cause of the problem shall be identified, which may be due to an

incorrect design or incorrect implementation. In the case of design errors, the Project Team shall review the design and make the necessary adjustments in the design. In some instances, changing design or implementation may require changes in the test data, which in turn may require a modification of the test plan.

An analysis and evaluation shall be done of all system documentation for completeness and a comparison made with the specifications for compatibility.

4.3.5 System Acceptance Test

A System Acceptance Test (SAT) Plan shall be developed that includes the step-by-step testing and inspection procedures to verify and demonstrate system compliance with the specifications. Final system acceptance tests shall be conducted after all the Subsystem tests have been successfully completed and all test results have been reviewed and accepted by the Project Team. Upon approval of the SAT, the SAT shall be used to test all hardware and software furnished and installed as part of the Project and to generate the documentation required for project completion and project acceptance. Acceptance testing shall be conducted to verify and demonstrate that all requirements have been completed and successfully demonstrated.

The Project requirements include:

- Operational
- Functional
- Performance
- Construction
- Installation
- Integration

4.3.5.1 Objective of Test

The SAT shall detail all tests to be performed, the test results which are expected and the test schedule.

The SAT shall include the following major test and acceptance categories:

- Performance tests
- Functional tests

If any material or documentation is outstanding or have been replaced under pre-acceptance warranty or during previous testing, a physical inspection shall be undertaken and documentation provided for this material per individual field element tests. The physical inspection shall consist of confirming all installed material to ensure workmanship satisfies the specified requirements. The contractor shall provide documentation to prove delivery of all material, equipment and software, cable and documentation.

The contractor shall test, in the presence of the Project Team, all integrated system functions to demonstrate that all circuits, cameras, arterial dynamic message signs, directional signs, traffic signal systems, detection subsystems, and all equipment and

software satisfies the functional requirements of the specifications. The Project Team may assist the contractor in conducting functional tests, as required and the contractor shall document all functional test results.

The system shall not have final system acceptance until all of the following conditions have been met successfully:

- All connections that were changed to perform acceptance tests are restored and tested
- All documentation has been completed and submitted to the Project Team
- Physical, performance and functional acceptance tests (ie. individual test plans) have been completed and the results are approved by the Project Team
- Upon successful completion of the individual field element tests, the contractor shall connect all hardware and software to form a fully operational system

4.3.5.2 Methodology

In the SAT, the entire System shall be tested to verify that each element is functional and all Subsystems are working together as a whole that meets the Contract Specifications and Detailed Design Requirements. This test shall be continuous and uninterrupted for thirty (30) consecutive calendar days after successful completion of integration testing with the System. Field elements shall operate continuously for twenty-four hours per day, seven days per week. Each field element shall experience no major failure during the testing period for final approval. A major failure shall be defined as having occurred when:

- Less than 95% of the component parts of any subsystem are in operation at any moment.
- Any failure that requires more than 24 elapsed hours to correct.
- Frequent occurrence of minor failures indicating a major system flaw, as determined by SMCTA and/or Caltrans.
- If a major failure occurs, the test clock shall be reset to zero and restarted after the fault is corrected.

For all events or inspection anomalies for test cases, a corresponding report shall be generated to describe the event, resolution responsibility, investigation results and final disposition.

Further details are provided in the section on “Testing Failures”.

4.4 Resources Needed For Testing

The resources needed by the contractor include a traceability matrix for the Project, qualified staff to perform the testing and any potential repairs; and all needed test equipment and simulated data if needed. The contractor shall utilize a compliance matrix to ensure that all physical and functional requirements as well as the hardware and software performance specifications are covered within the framework of acceptance testing and to verify that the installed system satisfies the original requirements and specifications. This traceability matrix shall also identify the general test method and any special resources or equipment and software (to be provided by the contractor) required

to conduct the tests. Final delivery of this matrix shall be submitted with the SAT submittal to ensure adequate testing coverage is performed.

4.5 Schedule and Test Duration

The contractor shall deliver the test procedures for review and approval by the Project Team at least two, but preferably three, weeks prior to the initiation of testing to allow for review and approval. Acceptance testing shall not commence until all material required by the project contract is delivered, installed and aligned and all manufacturer test results and Project Site test documentation have been approved by the Project Team. All acceptance test results shall be fully documented and such documentation provided as a condition of acceptance.

4.6 Stress Testing

Stress testing, as applicable, shall be performed to determine the performance of the hardware and software under the entire load of components on the project. Stress testing is a form of testing that is used to determine the stability of a given system or entity. It involves testing beyond normal operational capacity, often to a breaking point, in order to observe the results. In the case of the proposed System, the stress testing will involve testing the System with the maximum number of signal controllers, trailblazers, cameras arterial DMS and detectors. This will be done either through simulation or analysis. Further stress testing may be done at increased levels to the point where the performance is degraded to make the System unusable. Based on the results of the stress testing, performance adjustments shall be made to prevent system distortion or collapse.

4.7 Regression Testing

After integrating with other equipment and software subsystems, regression tests shall be performed to ensure that all previous hardware and software versions are still working. This may require changing the test data for previous equipment and software versions. All necessary revisions shall be made to the equipment and software and all necessary retesting and updating of the equipment and software versions performed as needed, based on the results of the test.

4.8 Testing Environment

The Project Team shall establish the environment in which to perform equipment and software testing at various levels (individual field components, portion of a system, full system, varying equipment loads/users, etc.). The Project Team shall ensure that each element of the environment performs its intended function. This environment shall also be used as the primary testing environment. The testing environment shall support testing at various levels identified in the testing plan for each baseline.

All active equipment and software shall be connected to normal operating power, energized and subjected to normal operating conditions for a continuous period of time. The functional tests shall be performed in accordance with an approved test plan. Any equipment or software that fails to meet the requirements shall be repaired or replaced and the test shall be repeated until satisfactory.

Bench-testing of contractor-furnished equipment shall take place at a contractor-provided facility. Equipment furnished by others shall be tested at the facility of those providing the equipment. Field testing shall occur at the site where the equipment is to be installed. The contractor shall provide or arrange for all necessary test equipment for performing the tests noted in the individual test plans for which it is responsible.

4.9 Testing Plan and Report Format

All testing reports and plans shall conform to the documentation standard formats in place for the Project. All test results, including results of failed tests or retests, shall be submitted and delivered with all hardware and software delivered to the Project Site. Full performance tests shall be performed by the manufacturer or by the contractor on all units of material. However, this is only applicable to hardware and software provided by the contractor. Where hardware and software is provided by others, bench-testing shall have been performed prior to delivery to the contractor. The full performance test shall be performed in accordance with an approved test plan. The tests shall demonstrate that the design and production of hardware and software meets the requirements of the contract. Full environmental testing shall be conducted by contractor or the manufacturer on hardware provided by the contractor.

4.10 Testing Failures

The contractor shall repair or replace any equipment on-site that fails during the warranty period within twenty-four hours of notification of the failure per the specifications. This shall include equipment removed from the site for repair or any equipment requiring replacement with a new unit. All costs associated with warranty-related replacement repairs shall be the sole responsibility of the contractor even in the instance when the equipment may be removed by others.

The contractor shall document each testing anomaly (any unexpected test result, malfunction or failure), its disposition and resolution. Details of each anomaly shall be documented in a System Discrepancy Report (SDR) and maintained with the test anomaly log.

The following provisions are defined to specify the applicable conditions, criteria and actions to manage events during acceptance testing activities and the sustained operations test period. For all events or inspection anomalies, a corresponding report shall be generated to describe the event, resolution responsibility, investigation results, and final disposition.

- A major failure shall be defined as having occurred when:
    - Less than 95% of the component parts of any sub-system are in operation at any moment. The sub-systems include Traffic Signal Subsystem, Directional Signs Subsystem, ADMS Subsystem, CCTV Cameras Subsystem, Detection Subsystem, and the Communications Subsystem
    - Any failure that requires more than 24 elapsed hours to correct

- Frequent occurrence of minor failures indicating a major system flaw, as determined by the Project Team

- A minor failure is any other failure. The SAT clock shall be stopped when a minor failure occurs and restarted without resetting to zero after the fault is corrected to the satisfaction of the Project Team.

- All failures and the corrective action taken, including component serial numbers, shall be maintained in a Failure Log and provided to the Project Team upon request.

- Data, as defined in specific paragraphs of the SAT test plan document, may be gathered outside the SAT period if previously coordinated and approved by the Project Team. The test log shall be appropriately annotated for these sections where a previously gathered test date has been used.

- The contractor shall respond to major failures of traffic signal systems and backbone communications related failures within two hours of notification. For all other major failures, the contractor shall respond within four hours of notification.

- The contractor shall respond to minor failures by the end of the next business day.

- The Project Team shall determine declaration of major failures. The SAT clock shall be reset to zero and restarted after the fault is corrected to the satisfaction of the Project Team.

- To satisfy the 24-hour, 7 days-per-week operational requirement, the system may be exercised during the SAT period in a normal operational mode rather than step-by-step sections of the SAT test plan document. Operational hours accumulated shall count toward the SAT period. These normal operational mode times shall be coordinated between the Project Team and the contractor and any suspected anomalies shall be reported to Project Team for disposition.

4.11 Failure Responsibility

In the event of a failure in the testing, responsibility for repairing the fault shall be dependent on identifying the location of the fault. It is expected that all parties shall work together in identifying the fault and its location. Lead responsibility for repairing the fault shall rest with the party responsible for whatever piece of hardware/software is causing the fault. Specifically, in the event of a failure of a subsystem or individual component that was not provided by the selected contractor, the entity that provided the subsystem or individual component shall be responsible for its repair. The contractor

shall remain responsible for identifying the item that failed during implementation and warranty.

Appendix 1
Test Plan Traceability Matrix

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.1.1	The System shall be able to collect and display data to support the following functions at local and inter-jurisdictional levels: • Traffic Operations • Recurrent Congestion Management • Non-recurrent Congestion/Incident Management • Special Event Management • Seasonal Traffic Management • Emergency/Disaster Managmergency/Disaster Management	System	Visual Inspection (done as part of other tests)	None	NA	NA	NA	Verify functionality	Contractor, Project Team				
4.1.2	The following Subsystems are expected to be deployed as part of the San Mateo Smart Corridors Program: Traffic Signal, Directional Signs, Arterial Dynamic Message Signs, CCTV Cameras, Detection, Communications	System	Visual Inspection	None	NA	NA	NA	Verify subsystems	Contractor, Project Team				
4.1.3	The System shall work with different makes and models of equipment intended for the same purpose	Field System	Demonstration	None	5 minutes per item (est.)	NA	NA	Verify ability to command and monitor equipment remotely	Contractor, Project Team				
4.1.4	The System shall provide compatibility with the Bay Area C2C Interface Control Document	System	Demonstration	None	24 hours	NA	NA	Verify ability to command and monitor from central system	Contractor, Project Team, Staff knowledgeable in C2C for the Bay Area				
4.1.4.1	NTCIP - C2C - 2304, 2305, & 2306	Field System	Demonstration	None	24 hours per each type/model of equipment	NA	NA	Verify ability to communicate between centers	Contractor, Project Team				
4.1.4.2	NTCIP - C2F - 1103, 1201, 1202, 1203, 1211, 2104, 2202, 2301, 2302, 1102, 2102	Field System	Demonstration	None	24 hours per each type/model of equipment	NA	NA	Verify ability to command and monitor equipment remotely	Contractor, Project Team				
4.1.5	The System shall implement only published standards with any amendments to be approved by Caltrans.	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.6	Standards shall include the following industry standards groups as applicable at a minimum:	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.6.1	NTCIP – Center-to-Center as modified for the Bay Area and as indicated in the San Mateo Smart Corridor Program ICD, dated July 2009.	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.6.2	NTCIP – Center-to-Field as indicated in the San Mateo Smart Corridor Program Interface Control Document (ICD), dated July 2009.	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.6.3	Society of Automotive Engineers (SAE) as indicated in the San Mateo Smart Corridor Program ICD, dated July 2009	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.1.6.4	Institute of Electrical and Electronic Engineers (IEEE) as indicated in the San Mateo Smart Corridor Program ICD, dated July 2009	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.6.5	American Association of State Highway and Transportation Officials (AASHTO) / Institute of Transportation Engineers (ITE) as indicated in the San Mateo Smart Corridor Program ICD, dated July 2009	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.6.6	National Electrical Manufacturers Association (NEMA)	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.6.7	Electronic Industries Alliance (EIA) / Telecommunications Industry Association (TIA)	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.6.8	Occupational Safety and Health Administration (OSHA)	Field System	Demonstration	None	NA	NA	NA	No variations from published standards.	Contractor, Project Team				
4.1.7	The System shall conform to current Caltrans policies, practices, and standards including: 2006 Standard Plans & Specs, 2009 TEES, Cal/OSHA, Assembly Bill 3418E	Factory Bench Field System	Demonstration, Visual Inspection	None	As Needed	NA	NA	System meets standards	Contractor, Project Team				
4.1.8	All field equipment shall meet the environmental requirements of the above noted Caltrans policies, practices, and standards	Field System	Demonstration	None	As Needed	NA	NA	No variations from published standards. Certification from manufacturer.	Contractor, Project Team				
4.1.9	System design shall provide backup capabilities to allow continuation of a satisfactory level of coordinated operation, should a local TMC, the SMCHub, the D4TMC, the communications hub, a communications link, a CCTV camera, a DMS, a directional sign or an intersection controller failure occur. A failure of a critical System component or intersection controller shall trigger corrective action to related adjacent intersections. (Satisfactory level is defined as the System not experiencing failure as defined previously.)	System 30-Day SAT	Simulation, Demonstration	None	1 hour of backup operation	NA	NA	TMC's should backup one another. Local device failures should not cause a system or subsystem failure	Contractor, Project Team				
4.1.10	The System shall include alarms to notify operators and maintenance personnel of System and device failures. Alarms shall be provided for the following conditions:	System and Subsystem	Simulation, Demonstration	None	Immediate upon failure	NA	NA	Alarm notifies operator	Contractor, Project Team				
4.1.10.1	Communications failure	System	Simulation	None	Immediate upon failure	NA	NA	Alarm notifies operator	Contractor, Project Team				
4.1.10.2	CCTV failure	System	Simulation	None	Immediate upon failure	NA	NA	Alarm notifies operator	Contractor, Project Team				
4.1.10.3	ADMS failure	System	Simulation	None	Immediate upon failure	NA	NA	Alarm notifies operator	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.1.10.4	Detector failure	System	Simulation	None	Immediate upon failure	NA	NA	Alarm notifies operator	Contractor, Project Team				
4.1.10.5	Directional sign failures	System	Simulation	None	Immediate upon failure	NA	NA	Alarm notifies operator	Contractor, Project Team				
4.1.10.6	Central hardware or software failure	System	Simulation	None	Immediate upon failure	NA	NA	Alarm notifies operator	Contractor, Project Team				
4.1.11	Alarms shall be user settable	System	Demonstration	None	N/A	NA	NA	Operator can set custom alarms	Contractor, Project Team				
4.1.12	It shall be possible to establish threshold levels for determining if a device or function has failed	System	Demonstration Simulation	None	Immediate upon reaching the threshold	NA	NA	Operator can customize alarm thresholds	Contractor, Project Team				
4.1.13	At the local level, the System shall be capable of interfacing with existing fiber networks and System-compatible controllers	Field System	Demonstration	None	24 hours per each type/model of equipment	NA	NA	System can incorporate System-compatible existing elements	Contractor, Project Team				
4.1.14	At the regional level, the System shall be capable of interfacing with the existing BART fiber backbone and with the D4TMC ATMS	System	Demonstration	None	Duration of Subsystem testing and SAT	NA	NA	System uses BART fiber and interfaces with ATMS	Contractor, Project Team				
4.1.15	The System shall have the capability of being expanded to cover the entire corridor in the County of San Mateo.	System	Analysis Simulation	None	1 hour	NA	NA	Inspection/analysis of system capacity shows sufficient capacity	Contractor, Project Team				
4.1.16	The System software shall have the capability of being expanded along the Smart Corridor in San Mateo County and being expanded to the following ultimate number of devices												
4.1.16.1	1024 CCTV	System	Analysis Simulation	None	1 hour	NA	NA	System software and hardware can meet requirement	Contractor, Project Team				
4.1.16.2	1024 ADMS	System	Analysis Simulation	None	1 hour	NA	NA	System software and hardware can meet requirement	Contractor, Project Team				
4.1.16.3	1024 Directional Signs	System	Analysis Simulation	None	1 hour	NA	NA	System software and hardware can meet requirement	Contractor, Project Team				
4.1.16.4	1024 Vehicle Detector Stations	System	Analysis Simulation	None	1 hour	NA	NA	System software and hardware can meet	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
								requirement					
4.1.16.5	1024 Signalized Intersections	System	Analysis Simulation	None	1 hour	NA	NA	System software and hardware can meet requirement	Contractor, Project Team				
4.1.17	As devices are added to the System, this shall only involve additions to the database without a reconfiguration or redesign of the System	System	Demonstration of each type of device	None	N/A	NA	NA	Adding a device only involves connecting it and defining the device within the database	Contractor, Project Team				
4.1.18	The System shall be capable of supporting all users concurrently without a noticeable change in System performance. The system view shall not be delayed by more than 2 seconds as compared to the pilot project when the system is at ultimate size.	System	Analysis Simulation	None	1 hour	Record delay upon querying the system (Pilot Project)	Record delay upon querying the system (Ultimate Size)	Delay is less than 2 seconds longer than pilot project delay.	Contractor, Project Team				
4.1.19	At the ultimate size, the operation of the field devices shall be unaffected by the additional devices with no increase in latency.	System	Analysis Simulation	None	1 hour	NA	NA	Adding elements does not decrease System performance	Contractor, Project Team				
4.1.20	The number of users allowed to be defined in the System shall be as follows and in the level of decreasing authority:	N/A											
4.1.20.1	*Administrative User* (1) - *overall control of all System functions and settings, including individually determining access rights for other levels of users*	System	Demonstration	None	N/A	NA	NA	Verify required number of users and privileges	Contractor, Project Team				
4.1.20.1.1	*Administrative users shall have the ability to add/modify/delete users* to specific user levels and within that level to specify what they can or cannot do.	System	Demonstration	None	N/A	NA	NA	Administrative users can modify accounts as described	Contractor, Project Team				
4.1.20.1.2	If a workstation is unused for an administrative user settable duration, the logon shall timeout and require the user to logon to access the System.	System	Demonstration	None	N/A	NA	NA	Unused workstations shall automatically log the user out	Contractor, Project Team				
4.1.20.1.3	In the event of an incident resulting in Caltrans assuming System control, Caltrans shall act as an administrative user.	System	Demonstration	None	N/A	NA	NA	Caltrans is the administrative user	Contractor, Project Team				
4.1.20.2	*Primary Users* (1024) - *ability to control and monitor all System functions.* This includes CCTV, ADMS, directional signs, intersection controllers and detection stations.	System	Demonstration	None	N/A	NA	NA	Verify required number of users and privileges	Contractor, Project Team				
4.1.20.3	*Secondary Users* (1024) - *ability to control and monitor a limited subset of all System*	System	Demonstration	None	N/A	NA	NA	Verify required number of	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	functions. These would be non-Caltrans elements within a specified jurisdiction.							users and privileges					
4.1.21	Each user account shall be unique	System	Demonstration	None	N/A	NA	NA	No duplicate accounts possible	Contractor, Project Team				
4.1.22	Where users of the same level are attempting to perform the same function, the user who initiated the action first shall have priority	System	Demonstration	None	N/A	NA	NA	Requirement met	Contractor, Project Team				
4.1.23	Where a user is overridden by another user, he/she shall receive a message notifying him of this action	System	Demonstration	None	N/A	NA	NA	Requirement met	Contractor, Project Team				
4.1.24	Users connected to the network and using a password and user identification shall be considered authorized users.	System	Demonstration	None	N/A	NA	NA	Requirement met	Contractor, Project Team				
4.1.25	Users shall be able to access the System via the Internet with the same privileges as if they were on a System workstation	System	Demonstration	None	N/A	NA	NA	System is accessible via the Internet	Contractor, Project Team				
4.1.25.1	Security measures shall be the same as those for a network connected user (encrypted password and user name and user level)	System	Demonstration	None	N/A	NA	NA	Login requires user name, password, and an encrypted connection	Contractor, Project Team				
4.1.26	A manual command shall override a system command	System	Demonstration	None	N/A	NA	NA	Requirement met	Contractor, Project Team				
4.1.27	Depending on their access level, users shall be able to perform the following actions:	N/A											
4.1.27.1	Modify central databases	System	Demonstration	None	N/A	NA	NA	User can modify	Contractor, Project Team				
4.1.27.2	Modify local/remote databases	System	Demonstration	None	N/A	NA	NA	User can modify	Contractor, Project Team				
4.1.27.3	Manually control field elements	System	Demonstration	None	N/A	NA	NA	User can manually control	Contractor, Project Team				
4.1.27.4	Establish schedules for field elements	System	Demonstration	None	N/A	NA	NA	User can set schedules	Contractor, Project Team				
4.1.27.5	View field elements data	System	Demonstration	None	N/A	NA	NA	User can view	Contractor, Project Team				
4.1.27.6	View field images	System	Demonstration	None	N/A	NA	NA	User can view	Contractor, Project Team				
4.1.28	During normal operations, each Agency shall have primary privileges over field elements in their own jurisdiction.	System	Demonstration	None	N/A	NA	NA	Agencies operate their equipment under normal conditions	Contractor, Project Team				
4.1.29	The System shall be capable of collecting and displaying the following information:	N/A											
4.1.29.1	Maintenance information which can be displayed or printed by device type, location, time of day/date. Maintenance information shall include status, and if failed, the time/date of failure and the reason for the failure.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.1.30	The CCTV cameras shall be capable of being placed in at least four independent camera tours per workstation	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.31	The SMCHub shall normally control and monitor the local field devices that are not owned by Caltrans. This shall continue until such time as local TMCs come into existence.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.32	The SMCHub shall take over for Caltrans in the event the D4TMC becomes unavailable. Caltrans shall be able to operate the system through a leased line to the SMC Hub.	System	Demonstration	None	3 hours	NA	NA	Verify that SMCHub can manage system w/o link to D4TMC	Contractor, Project Team				
4.1.33	The primary GUI shall be an interactive map that displays current status of the roadway network and ITS field elements.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.34	Data shall be geographically referenced on the NAD 83 (NAVD 88) California Coordinate System.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.35	All actions by users shall be logged with the time, date, user identification and the action taken.	System	Demonstration	None	3 hours	NA	NA	All actions are shown in a log	Contractor, Project Team				
4.1.36	The System shall provide a user with spell check, text wrapping and copy/cut/paste capabilities on reports and sign messages.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.37	The user shall be able to specify the format of reports and the data to be included in the reports.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.38	*The System shall have the ability to create reports* containing current and historical data. *The System shall support the ability for multiple users to monitor the same data items.*	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.39	The System shall not require input from other systems to function.	System	Demonstration	None	30 days	NA	NA	System functions without outside input	Contractor, Project Team				
4.1.40	The System shall support compliance with all interagency agreements.	Field System	Analysis	None	N/A	NA	NA	Requirements of Interagency agreements can be implemented within System	Contractor, Project Team				
4.1.41	Subsystems shall continue to operate with the same functions in the event that other Subsystems are not available. If communications still exist, the Subsystems shall have full functionality. If communications does not exist, the field devices shall be capable of being operated locally either manually or on a time of day basis as applicable.	System	Demonstration	None	1 hour per Subsystem/type of equipment	NA	NA	Requirement is met	Contractor, Project Team				
4.1.42	Each Subsystem shall be able to perform the same functions as a standalone system that it shall perform within the integrated	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	System												
4.1.43	In the event of a power failure at the D4TMC, the SMCHUB, the local TMCs, or at the field elements, the affected System/Subsystem/field element shall revert to the power backup available locally	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.44	Through the use of external cabinets or by having equipment in separate cabinets, it shall be possible to establish a demarcation point for defining the limits of maintenance responsibility for communication lines, all field equipment and all TMC equipment	Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.45	Upon confirmation of a major incident on US 101, Caltrans shall have the ability to take over control of all ITS devices on affected local roadways	System	Demonstration	None	N/A	NA	NA	Verify ability to command and monitor equipment remotely	Contractor, Project Team				
4.1.45.1	The initial response to a major incident shall involve the automatic implementation (following Caltrans user approval) of a predetermined response plan	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.45.2	Caltrans shall have the ability to select response plans manually and to manually change all timing plans	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.45.3	Local TMCs and the SMCHUB shall maintain the ability to monitor ITS devices in a manner identical to that prior to their takeover by Caltrans	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.45.4	Local agencies shall not be able to control any System elements once Caltrans has implemented a response plan	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.45.5	Local agencies shall have the ability to view the signal timing plans in effect and any changes made to them by Caltrans	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.46	The System shall synchronize clocks with all field devices using Pacific Standard Time.	System and Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.47	Within each Subsystem, the components shall be capable of being added in a modular fashion.	Field System	Demonstration	None	N/A	NA	NA	Components can be swapped/ added independent of each other	Contractor, Project Team				
4.1.49	Proprietary protocols shall be used only when necessary to communicate to legacy and third party devices that do not support NTCIP communications protocols. To facilitate exchange of information, the standards/interfaces not specified elsewhere in this document shall be non-proprietary, well-documented, capable of	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	being implemented by several firms, in widespread use, supported and maintained by national organizations and follow industry standards.												
4.1.50	Changes in the database resulting from future expansion and additional ITS elements shall involve a smooth and seamless integration.	System	Demonstration	None	N/A	NA	NA	System can tolerate failure in individual components or links without crashing.	Contractor, Project Team				
4.1.51	The System shall have a standalone interface for a user in the D4TMC until such time as the System is integrated into the D4ATMS at which time the interface shall be transparent to the user in the D4TMC	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.52	It shall be transparent to the user whether the System is a single system or multiple, interconnected systems.	System	Demonstration	None	N/A	NA	NA	The operator can input operator commands without changing systems (ie. without new logons, etc.)	Contractor, Project Team				
4.1.53	The System provided shall demonstrate three different examples of successful operations and integration with other established and similar Systems.	System	Analysis Demonstration	None	N/A	NA	NA	Other installed systems show this requirement being met.	Contractor, Project Team				
4.1.54	The System shall be vendor- and model-independent	System	Analysis Demonstration	None	N/A	NA	NA	System can operate on multiple platforms	Contractor, Project Team				
4.1.55	The delivered and installed System shall be fully documented. This documentation shall consist of pertinent technical documentation and user documentation sufficient to maintain and operate the System	System	Analysis Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.56	Software and hardware shall be reliable. Reliability shall be measured by the following methods:												
4.1.56.1	The percentage of time that the System is available for use shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance which should not involve shutting down the System or any Subsystem longer than 1 hour in a 30-day period.	System	Analysis	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.56.2	In the event of a power failure, the System shall resume normal scheduled operation within 5 minutes of restoration of power. Normal operation is defined as operation of the complement of devices meeting the	System	Analysis Demonstration	None	30 days	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	performance requirements and providing the functionality noted herein.												
4.1.56.3	System failure shall occur when the user is unable to access the System and perform normal operations; when more than 10% of a given type of ITS element is not available; when more than 10% of the total ITS elements are not available for use. Power failures at field locations are not to be counted in these calculations.	System	Demonstration	None	5 minutes	NA	NA	Requirement is met	Contractor, Project Team				
4.1.56.4	In the event of a failure or the System not meeting the performance requirements, the System shall be considered not meeting the system requirements.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.1.57	System performance measures shall be based on reliability measures and on the following:												
4.1.57.1	Displays shall be available within 2 seconds after a user command	System	Demonstration	None	2 seconds	NA	NA	Requirement is met	Contractor, Project Team				
4.1.57.2	Screen updates shall occur within 2 seconds	System	Demonstration	None	2 seconds	NA	NA	Requirement is met	Contractor, Project Team				
4.1.57.3	These requirements shall apply to items including but not limited to status reports, detector data reports, directional sign message reports, and CCTV images.	System	Demonstration	None	2 seconds	NA	NA	Requirement is met	Contractor, Project Team				
4.2.1	Within a jurisdiction, the Subsystem shall be capable of the following modes of operation on a sytem-wide basis, a group basis, or as individual intersections:	N/A											
4.2.1.1	Time-of-day operation	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.1.2	Traffic-responsive operation	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.1.3	Manual operation	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.1.4	Flash operation	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.1.5	Free actuated operation	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.2	Traffic responsive operation shall be based on a combination of occupancy and volume data from system detectors	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.3	The application shall launch and operate within a web browser and shall not utilize any 3rd party remote web access, web application delivery or virtual networking tools to achieve/simulate a web application.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.4	The map shall be GIS based using standard GIS files (e.g. .shp files or other equivalent) to render a geographically accurate, to-scale map.	System	Demonstration	None	N/A	NA	NA	Software can run on multiple platforms	Contractor, Project Team				
4.2.5	The Subsystem shall provide authorized users the capability to view the following	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	signalized intersection information:												
4.2.5.1	Location and jurisdiction	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.5.2	Signal controller and vehicle detection hardware	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.5.3	Communication type and status	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.5.4	Signal controller status defined by AB 3418	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.5.5	All user-settable signal controller parameters	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.5.6	Alarms	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.6	The Subsystem shall provide authorized users the capability to alter signal controller parameters listed in 4.3.2.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.7	The Subsystem shall be capable of restricting the alteration of signal controller parameters listed in 4.3.3.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.8	The Subsystem shall allow groups of controllers to be created and controlled independent of jurisdictional boundaries	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.9	*The Subsystem shall allow signal coordination across jurisdictional boundaries.*	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.10	Users can assign intersections to groups on a time of day basis and on a traffic responsive basis.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.11	The Subsystem shall utilize a common system time reference and clocks shall be synchronized at least once every hour	Bench Field System	Demonstration	None	24 hours	NA	NA	Requirement is met	Contractor, Project Team				
4.2.12	Authorized users shall be able to select the Subsystem's mode of operation at any time.	System	Demonstration	None	72 hours	NA	NA	Requirement is met	Contractor, Project Team				
4.2.13	The Subsystem shall provide data on intersection operation including timing plans and intersection status which can be displayed or printed by intersection name or intersection number.	System	Demonstration	None	5 minutes	NA	NA	Requirement is met	Contractor, Project Team				
4.2.14	The Subsystem shall provide historical signal timing data which can be displayed or printed by time-of-day, interval, location and group	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.15	Once an operating mode is selected, the Subsystem shall begin implementation of selected mode within one cycle length.												
4.2.16	In the event of a loss of communications to a Subsystem being controlled at the SMCHub or D4TMC level, the Traffic Control Subsystem shall revert to local control/time of day schedules	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.16.1	If communication to a controller is lost, the controller shall continue to operate under the most recent mode of operation	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	to the extent possible												
4.2.16.2	If communication to a group of controllers is lost, the group shall continue to operate under the most recent mode of operation to the extent possible	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.2.17	The Traffic Control Subsystem shall have the following performance measures:												
4.2.17.1	The percentage of time that the Subsystem is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.	30 Day SAT	Demonstration	None	30 days	NA	NA	Requirement is met	Contractor, Project Team				
4.2.17.2	In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.	System	Demonstration	None	3 minutes	NA	NA	Requirement is met	Contractor, Project Team				
4.3.1	*Controllers shall be capable of operating under the following modes:*	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.1.1	Time of day operation	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.1.2	Traffic responsive operation	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.1.3	Manual operation	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.1.4	Flash operation	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.1.5	Free actuated operation	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.2	Controllers shall be able to receive and implement timing plans from the System that alter the following parameters:												
4.3.2.1	Splits	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.2.2	Cycle lengths	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.2.3	Green extensions	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.2.4	Offsets	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.3.2.5	Lead/Lag	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.2.6	Recalls	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.2.7	Phase Omit	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.2.8	Clearance Times	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.2.9	Gap Times	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.3	The Subsystem shall provide processing of emergency vehicle preemption.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.4	The Subsystem shall have the capability to export signal timing plan data.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.5	Controllers shall be capable of storing at least 32 unique signal timing plans	Bench Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.6	Controllers shall continue to operate normally during all communication polling and database transfers.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.7	Controllers shall meet either NEMA TS2, or be compatible with Model 2070 or Model 2070 Lite requirements in the TEES	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.3.8	Controllers shall have the following performance measures:												
4.3.8.1	The percentage of time that a controller is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.	30 Day SAT	Demonstration	None	30 days	NA	NA	Requirement is met	Contractor, Project Team				
4.3.8.2	In the event of a power failure, the controller shall resume normal scheduled operation within 3 minutes of restoration of power. (Normal as previously defined.)	Field	Demonstration	None	3 minutes	NA	NA	Requirement is met	Contractor, Project Team				
4.4.1	The Directional Sign Subsystem shall be composed of signs noting the direction of travel (trailblazers) and signs prohibiting specified directions of travel.	System	Visual Inspection	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.4.2	Trailblazer signs shall direct the motoring public to designated routes through the use of arrows.	System	Visual Inspection	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.3	*The Subsystem trailblazer signs shall be capable of displaying non-flashing and flashing arrows.*	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.4	*Trailblazer signs shall have a dynamic arrow capable of showing multiple directions either singly or concurrently.*	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.5	Trailblazer signs shall be uniquely identifiable.	Field	Visual Inspection	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.6	Turn prohibition signs shall be blankout signs	Bench	Visual Inspection Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.7	*The Subsystem shall be able to report the status of all sign hardware*	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.8	Sign placement shall conform to the Manual of Uniform Traffic Control Devices (MUTCD).	Factory	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.9	The Subsystem shall allow sign messages to be centrally validated. Validation shall consist of checking the authority of the user, and verifying the sign is off or the correct arrow display is being displayed.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.10	Users shall have the capability to poll a directional sign to view/confirm current sign displays, equipment status, and to test communications.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.11	The Subsystem shall be able to automatically report the status of all internal electronic components, and communication equipment.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.12	The Subsystem shall be capable of displaying messages on a scheduled basis with the start/end times established by the user.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.13	The sign controller shall be able to retain user and scheduled plan commands in the event of a sign failure or loss of communications to a sign and implement these commands when the sign resumes normal function if the command is valid	Bench Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	and has not expired.												
4.4.14	The Subsystem shall be capable of displaying messages for a user-settable length of time.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.15	The user shall be able to implement a command to a single sign or a group of signs at once.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.16	Turn prohibition signs shall comply with MUTCD.	Bench	Visual Inspection	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.4.17	Directional signs shall have the following performance measures												
4.4.17.1	The percentage of time that the Subsystem is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.	30 Day SAT	Demonstration	None	30 days	NA	NA	Requirement is met	Contractor, Project Team				
4.4.17.2	In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.	Bench Field	Demonstration	None	3 minutes	NA	NA	Requirement is met	Contractor, Project Team				
4.5.1	*The Subsystem shall allow sign messages to be centrally validated.* Validation shall consist of checking the authority of the user, spell check, comparing the message against a list of unacceptable words and viewing message content.	Bench, Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.2	Users shall have the capability to manually poll an ADMS to view/confirm current sign messages, equipment status, sign temperature and to test communications.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.3	The Subsystem shall be able to automatically report the status of all sign hardware including individual pixels, internal electronic components, temperature and communication equipment.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.4	The Subsystem shall be capable of displaying messages on a scheduled basis with the start/end times established by the user.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.5.5	The Subsystem shall be capable of displaying messages for a user-settable length of time.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.6	The user shall be able to compose or retrieve a message and post it to a single sign or a group of signs at once.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.7	The user shall be able to blank a sign or a group of signs at once.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.8	The user shall be able to view a message before it is transmitted, and the users view shall be the same as what is displayed on the sign (WYSIWYG) with an exact pixel representation.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.9	The Subsystem shall be capable of displaying either a 1 or 2 phase message.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.10	Each ADMS shall display 2 lines of text with 12 12-inch high characters per line.	Bench	Visual Inspection	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.11	The sign controller shall be able to retain user, scheduler, and response plan commands in the event of a sign failure or loss of communications to a sign and implement these commands when the sign resumes normal function if the command is valid and has not expired.	Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.12	The Subsystem shall support NTCIP 1203 (Ver. 2.35a Published 2007)	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.5.13	ADMS shall have the following performance measures:												
4.5.13.1	The percentage of time that the Subsystem is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.	30 Day SAT	Demonstration	None	30 days	NA	NA	Requirement is met	Contractor, Project Team				
4.5.13.2	In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.	Bench Field	Demonstration	None	3 minutes	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.6.1	*The Subsystem shall support the video monitoring of selected arterial locations and midblock locations to provide information regarding* traffic conditions.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.2	*Each CCTV camera shall transmit a color image.*	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.3	*Camera images shall conform to National Television System Committee (NTSC) standards.*	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.4	The user shall be able to select and view any CCTV camera in the Subsystem.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.5	CCTV images from all cameras shall be viewable sequentially (camera tours), individually or simultaneously as a group.	Field System	Analysis, Simulation	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.6	All video shall be a minimum of 10 frames per second	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.7	The Subsystem shall support both PTZ and fixed cameras.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.8	CCTV cameras shall have multiple control functions such as focus, presets, iris adjustments as well as pan, tilt and zoom (if so equipped) which can be accessed locally and remotely.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.9	The Subsystem shall support serial and/or IP communication for camera control.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.10	The Subsystem shall support multiple camera controllers using different protocols.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.11	Each video image shall have a unique identification which can be modified by a user with a suitable access level.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.6.12	The capability shall exist to share control of cameras among agencies within the corridor including Caltrans.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.6.14	The CCTV Subsystem shall have the following performance measures:	Field System											
4.6.14.1	The percentage of time that the Subsystem is functioning shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.	30 Day SAT	Demonstration	None	30 days	NA	NA	Requirement is met	Contractor, Project Team				
4.6.14.2	In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.	Bench Field	Demonstration	None	3 minutes	NA	NA	Requirement is met	Contractor, Project Team				
4.7.1	The Subsystem shall provide for measurement of traffic parameters (speed, volume and occupancy on a per lane basis) at selected locations.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.7.2	The Subsystem shall provide volume, speed, occupancy and status data which can be displayed or printed by time period, location, lane, station and group.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.7.3	The Subsystem shall collect data at a minimum data accumulation period of once every 30 seconds.	Bench System	Demonstration	None	1 minute	NA	NA	Requirement is met	Contractor, Project Team				
4.7.4	After the end of each data accumulation period, the data for that time period shall be made available to the System.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.7.5	The Subsystem shall provide historical detector data which can be displayed or printed by time of day, interval, location and group.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.7.6	The System shall be capable of interfacing with all legacy vehicle detector sensors.	Field, System	Demonstration Analysis	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.7.7	System detectors shall collect/calculate volume, occupancy, and speed data independent of local signal controller actuation and detection functions.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.7.8	The Detection Subsystem shall have the following performance measures:												
4.7.8.1	The percentage of time that the Subsystem is functioning per the specifications shall be at least 99.8% measured over a 30-day period. This excludes scheduled maintenance.	30 Day SAT	Demonstration	None	30 days	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.7.8.2	In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power.	Bench Field	Demonstration	None	3 minutes	NA	NA	Requirement is met	Contractor, Project Team				
4.8.1	The Communications Subsystem shall be able to incrementally increase or decrease in size with limited cost and risk as the need to add or remove equipment becomes necessary. A design utilizing modular communication equipment shall be provided.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.2	The Communications Subsystem shall be capable of supporting any combination of private twisted-pair copper, fiber optic, and/or wireless radio.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.3	The Communication Subsystem shall support serial and Ethernet based communications.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.4	The Communications Subsystem shall provide capability for center-to-field (C2F) communications connecting and supporting all ITS (CCTV video surveillance, arterial detection, directional and arterial dynamic message signs) and various traffic signal field devices within the project area with the San Mateo County Hub (SMCHub) and the Caltrans District 4 Transportation Management Center (D4TMC).	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.4.1	The Communications Subsystem shall include Hubs at selected locations along the corridor to aggregate communications network data and video and support alternate configurations up to the ultimate system size.	System	Analysis, Simulation	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.4.2	Provide direct Ethernet communications between the HUBs and the SMCHub.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.4.3	The Communications Subsystem shall support interconnect and coordination between local agency traffic signal systems on local streets (local TMCs/TOCs), the SMCHub and State operated traffic signals on State routes (D4TMC).	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.5	The Communications Subsystem shall provide capability for center-to-center (C2C) communications between the proposed SMCHub and the D4TMC.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.5.1	Provide a SONET OC-X node (as determined by Caltrans) at the SMCHub to create a redundant SONET ring through the existing Caltrans SONET backbone network connecting the SMCHub, D4TMC, SFGo TMC	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	and others.												
4.8.5.2	Support and provide compatibility with the on-going Smart Corridor C2C Interface Control Document (ICD) and central software initiatives.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.6	*The SMCHub shall serve as the central local control point of the Smart Corridor and serve as back-up for Caltrans D4TMC operations.*	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.7	New backbone fiber optic cable shall be a minimum of 72 single mode fibers or as required during design with a minimum of one (1) buffer tube allocated for backbone communications purposes only.	Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.8	New spur (drop) fiber optic cable shall be sized for the application.	Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.9	Communications equipment shall include Ethernet switches. Each switch shall provide at least eight (8) copper ports (sized for application during design) with a minimum speed of 100 Mbps and two pluggable, single-mode 100/1000 Mbps full duplex fiber ports for "daisy-chain" applications. Optical transceivers shall be as required to meet link loss budget requirements determined per the design.	Bench Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.10	All field Ethernet switches shall support, at a minimum; multicast routing (IGMP snooping), Virtual LAN (802.1Q), Simple Network Management Protocol (SNMP) capable, Spanning Tree Protocol / STP (IEEE 802.1D including the rapid spanning tree protocol / RSTP extension) and browser-based management interface.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.11	Any wireless communications providing access to and control of multiple ITS devices or creating a link to multiple wireless devices shall be considered to be part of the communications backbone.	Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.12	All design of wireless links shall include a full path analysis as required.	Field	Analysis	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.13	The communications network shall provide sufficient bandwidth and network configuration to support full motion video up to 30 frames per second (with a minimum of 10 frames per second) from all cameras andl field data devices simultaneously as part of this System. Any camera shall be able to be viewed simultaneously by any and all operators and/or authorized users with network connectivity.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.8.14	All communications field equipment shall be hardened complying with the NEMA TS1 and TS2 Environmental Requirements for traffic control equipment. Where there is a conflict with other requirements, the more stringent requirement shall apply.	Bench Field	Demonstration Analysis	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.15	All communications field equipment shall be protected and able to maintain normal operations under local adverse roadway conditions including; wind blown dust, dirt, rain, salt environment, etc.	Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.16	The Communications Subsystem shall be expandable to accommodate at least 25% more field devices of each type than currently planned and accommodate a minimum of 30% excess bandwidth for future network traffic.	System	Demonstration Analysis	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.17	The communications network and associated equipment shall be readily and safely accessible for maintenance and capable of being maintained by electronic technicians with a normal skill set and equipment normally available for maintenance of a fiber optics and/or wireless communication system as applicable.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.18	Diagnostics shall be provided via visual displays on the equipment or output to a port connected to a laptop.	Bench Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.19	The Subsystem shall include a network management system (NMS) providing the following minimum features:												
4.8.19.1	Provide a graphical, layered view of the communication system architecture.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.19.2	Manage the bandwidth of the network.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.19.3	Configure the network and diagnose network problems from a remote location.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.19.4	Report system status.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.19.5	Monitor network performance.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.19.6	Alert user during cable cut, hub failure, and system failure.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
4.8.19.7	Provide automatic recovery with RSTP. The System shall provide a recovery time of less than five (5) seconds using industry-standard protocols.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.19.8	Provide databases for storing data that fully and precisely defines and describes every element (communication link, levels and device) in the communications system.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.19.9	Allow event logging and reporting.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.20	The Subsystem shall include back-up power systems for communications network equipment for directional signs, hubs and traffic signals in all field cabinets, HUBs, and TMCs and other designated facilities. Run-time shall be determined during design.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.21	ITS devices requiring different transmission speeds and communication protocols shall be capable of coexisting on the same communication channel.	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.22	The same type of ITS device from multiple manufacturers shall be capable of operating on the same communications channel (interchangeable).	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.23	Multiple types of ITS devices from multiple manufacturers shall operate on the same communications channel (interoperability).	Field System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.24	The communication equipment specified in the design shall demonstrate technology maturity (been in use at least three years in similar systems) through successful operations and integration with other established and working systems.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.25	The Subsystem shall provide the following security measures at a minimum:	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.25.1	Firewalls at facilities as required and approved by Caltrans.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.25.2	Computer workstations shall include user passwords and administrative privileges supporting different levels of control prioritization as approved by Caltrans.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.25.3	Field network devices shall include password security, remote access security, SNMP authentication and encryption, secure web authentication and encryption, Radius support, port security and MAC filtering, at a minimum.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.25.4	Physical security measures for Field Cabinets, HUBs, pull boxes, and facilities	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix

Detailed Design Requirements Reference	Requirement Description	Test Type	Test Method(s)	Test Equipment	Test Duration	Data In	Data Out	Expected Results	Staff Needed				
	shall be provided to mitigate unauthorized entry and vandalism.												
4.8.26	The Communication Subsystem shall have the following performance measures:												
4.8.26.1	Point-to-point wireless serial communications may be unlicensed wireless communications (frequency hoping, spread spectrum). Bandwidth shall be determined during detailed design depending on type of device (i.e., data only, video, etc.).	Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.26.2	Any Broadband wireless (backbone) radios contained in the communications backbone for this project shall provide a minimum bandwidth of 50 Mbps full-duplex / 100 Mbps aggregate. The first backbone link shall have a round trip latency not to exceed three (3) milliseconds with an additional five (5) milliseconds for every repeater (hop) as required after that (if the System will be using licensed “carrier-grade” equipment) or 10 milliseconds per hop (if using unlicensed equipment). All system reliability and uptime calculations shall be determined during design and approved by Caltrans.	Field	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.26.3	Overall Communications Subsystem network backbone uptime (uptime being the Communications Subsystem is available to perform the required tasks) shall meet or exceed 99.5% over a 30-day period or as determined during design. This excludes scheduled maintenance.	30 Day SAT	Demonstration	None	30 days	NA	NA	Requirement is met	Contractor, Project Team				
4.8.26.4	The Communications Subsystem shall have an error rate of less than one (1) in a million.	Bench	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.8.26.5	In the event of a power failure, the Subsystem shall resume normal scheduled operation within 3 minutes of restoration of power. (Normal as previously defined.)	Bench Field System	Demonstration	None	3 minutes	NA	NA	Requirement is met	Contractor, Project Team				
4.8.26.6	The Communications Subsystem shall provide for a video latency (from video encoder to decoder) of less than 400 millisecond maximum latency (or as directed by Caltrans).	Bench System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.9.1	Shared Video: All video images from CCTV cameras located within the project should be accessible to any jurisdiction or local agency throughout the corridor on any remote computer attached to the network.	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				
4.10.1	The connection between the local agency TMCs (if they exist) and each other as well as their connection to the D4TMC shall be	System	Demonstration	None	N/A	NA	NA	Requirement is met	Contractor, Project Team				

Detailed Design Requirements Test Plan Traceability Matrix													
Detailed Design Requirements Reference	**Requirement Description**	**Test Type**	**Test Method(s)**	**Test Equipment**	**Test Duration**	**Data In**	**Data Out**	**Expected Results**	**Staff Needed**				
	through the SMCHub.												